

Advances in Cognitive Architectures and Artificial Intelligence

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Abstract 7H[WLOH VXEVWUDWHV DUH HQGRZHG ZLWK IOH[LELOLW\ DQG HDVHRIPDNLQJ±XSEXWUDUHQRQFRQGXFWRUVRIHOHF WULFLW\&RQGXFWLYH PDWHULDOV OLNH FDUERQ FDQ EH LQFRUSRUDWHG LQWR WH[WLOH VWUXFWXUHV WR PDNH IOH[LEOH FRQGXFWLYH PDWHULDOV 6XFK FRQGXFWLYH WH[WLOHV ILQG DSSOLFDWLRQV DV HOHFWURVWDWLF GLVFKDUJH PDWHULDOV HOHFWURPDJQHWLF VKLHOGLQJPDWHULDOVDQGIOH[LEOHPDWHULDOVWR FDUUFXUHQWVRUWLQDOV 7KLVZRUNIRFXVHVVRQXVHRIFDUERQILEHUDVFRQGXFWRURIHOHFWULFLW\ &DUERQ ILEHUV LQ VWDSOH RU WRZ IRUP FDQ EH LQFRUSRUDWHG LQ WH[WLOH \DUQVWUXFWXUHWFRQGXFWHOHFWULFLW\7KHSDS HUKLJKOLJKVWVKHSURFHVV IRUGHYHORSHPHQWRIWKHVFRQGXFWLYH\DUQVRISRO\ HVWHUFDUERQXVLQJ)ULFWLRQ VSLQQLQJ'5() DV ZHOO DV ULQJ VSLQQLQJ 7KH RSWLPLJHG SURFHVVSDUDPHWHUVIRUSURFHVVVLQJKEULGVWUXF WXUHRISRO\HVWHUZLWK FDUERQWRZRQ'5()VSLQQLQJDQGSRO\HVWHUZLWKFDU ERQVWDSOHILEHU XVLQJ ULQJ VSLQQLQJ KDYH EHHQ SUHVHQWHG 7KH VWXGLHV KDYH EHHQ OLQNHGWRKJLJKOLJKVWKHHOHFWULFDQFRQGXFWLY LWRIWKHGHYHORSHG\DUQV)XUWKHUWKHGHYHORSHG\DUQVKDYHEHHQLQFRUSR UDWHGDVZHIWLQIDEULF DQG WKHLU HOHFWULFDQ FRQGXFWLYLW\ KDV EHHQ HYDOXDWHG 7KH SDSHU GHPRQVWUDWHVWKHVWUXFWXUHQDQGSURSHUWLHV RIIDEULFVGHYHORSHGIRUP VXFKSRO\HVWHUFDUERQEOHQG\DUQVDQGWKHLUVXL WDELOLW\DVHOHFWULFDQO\ GLVVLSDWLYHIDEULFV

Keywords &DUERQILEHUK\EULG\DUQVHOHFWURVWD WLFGLVVLSDWLYH IDEULFV

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& \$5%21DWDQDWRPLFOHYHOKDVVKHSRWHQWL DOWREHDJRRG &DUERQ ILEHUV DUH JUDSKLWLF IRUPV GHULYHG IURP GLIIHUHQW SUHFXUVRUV YL] SRO\DFU\ORQLWLOH DQG SLWFK 7KH ILEHUV KDYH KLJKVWUHQJWKDQGDUHILQHDERXWPLFURQLQGLD PHWHU7KHVH ILEHUVPD\EHLQWRZIRUPQRPHQFODWXUHDV..RU. LPSO\LQJ WKHQXPEHURI ILODPHQWV LQ WKH WRZ 6LPLODUO\ WKH

ILEHUVIURP3\$1EDVHGSUHFVUVRUDUHUDQJLQJIRP' WR 'DQGDUDHYDLODEOHLQYDU\LQJVWDSOHOHQJWKV RIWRPP 7KHSLWFKEDVHGILEHUVKDYHKLJKHUHOHFWULFD OFRQGXFWLYLW\DV

0DQLVKDS+LUDLVZLWKWKH7H[WLOH0DQXIDFWXUHV'HSDU WPHQW9HHUPDWD -LMDLEDL 7HFKQRORJLFDQ ,QVWLWXWH 9-7, 0DWXQJD 0XPEDL ± ,QGLD SKRQHHPDLOPDQHHUDDMD#JPDLOFRP

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7H[WLOH PDWHULDOV WUDGLWLRQDOO\ DUH QRQFRQGXFWRUV RI HOHFWULFLW\7KHHUDRIJURZLQJHOHFWURQLFVDQ GVPDUWPDWHULDOV GHPDQGV WKH GHYHORSHPHQW RI IOH[LEOH FRQGXFWLYH PDWHULDOV 7KHVHFDQEHGHYHORSHGELPSDUWLQJHOHFWULFD OFRQGXFWLYLW\WR WH[WLOH VXEVWUDWHV &RQGXFWLYH PDWHULDOV FDQ EH LQFRUSRUDWHG LQWR WH[WLOH VWUXFWXUHV XVLQJ YDULRXV WHFKQLTXHV 0HWDOOLF ILODPHQWV FRXOG EH SOLHG WR IRUP D FRQGXFWLYH \DUQ RU HPEURLGHUHG RQWR WKH IDEULF VXEVWUDWHV &RDWLQJ RI WH[WLOH VXEVWUDWHV ZLWK PHWDOOLF SLJPHQWV LV \HW DQRWKHU PHWKRQ RI PDNLQJ FRQGXFWLYH VXEVWUDWHV (YHQ FRDWLQJ ZLWK RUIJQLF SRO\PHUVOLNHSRO\DQLOLQHRUSRO\S\UROHFDQEH XVHGRUFRDWLQJ ZLWKFDUERQQDQRPDWHULDOVFDQEHWULHGIRUP DNLQJFRQGXFWLYH WH[WLOHV >@ >@ 7KH SUHVHQW IRFXV LV PDNLQJ RI FRQGXFWLYH \DUQVIHZRIWKHDSSURDFKHVKDYHEHHQLQFRUSRU DWLQJDFRUHRI D FRQGXFWLYH PHWDO OLNH FRSSHU LQWR \DUQ VWUXFWXUH 6HYHUDO VWXGLHV KDYHEHHQUHSRUWHGRQPDNLQJFRQGXF

WLYH\DUQVXVLQJ
YDU\LQJJDJXHVRIFRSSHUFRUHZLWKYDU\LQJVKHD
WKPDPDWHULDOV OLNH FRWWRQ SRO\HVWHU RU
SRO\SURS\OHQH ORVW RI WKH GHYHORSHPHQW KDV
EHHQ RQ '5() VSLQQLQJ RQO\ >@>@ 6LPLODUO\
UHDUGLQJ WKH GHYHORSHPHQW RI FRQGXFWLYH
\DUQV XVLQJ FRQYHQWLRQDO WHFKQLTXH
VHYHUDO ILEHUV KDYH EHHQ EOHQGHG 7KH
FRQGXFWLYH ILEHUV LQ WKH IRUP RI YHU\ ILQH
VWDLQOHVVVWHHOKDYHEHHQXVHG>@
(OHFWULFDUHVVLVWDQFHRIDPDWHULDOLQGLFD
WHVKRZVWURQJO\WKH
PDWHULDORSSRVHVWKHRIORZRIHOHFWULFFXUUHQ
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RQWKHHOHFWULFDUHVVLVWDQFHRIDPDWHUL
DOVFRQGXFWLYHWH[WLOHV
FDQEHFODVVLILHGDV,QVXODWRUVUHVVLVWDQFHJ
UHDWHUWKDQ□
'LVVLSDWHUVUHVVLVWDQFHUDQJHWR□DQG&RQGX
FWRUV UHVVLVWDQFH OHVV WKDQ □ 'HSHQGLQJ
XSRQ WKH OHYHO RI FRQGXFWLYLW\ WKH WH[WLOH
PDWHULDORV ILQG DSSOLFDWLRQV DV VXEVWUDWH
WR GLVVLSDWH VWDWLF HOHFWULFLW\ WR FDUU\
HOHFWULFDO FXUUHQW RU GDWD VLJQDOV RU DV
PDWHULDORV WR VKLHOG
7KH SUHVHQW VWXG\ KDV H[SORUHJ WKH
SRVLELOLW\ RI LQFRUSRUDWLRQJ WZR IRUPV RI
FDUERQ ILEHU LQWR WH[WLOH \DUQ
VWUXFWXUHV7KHPHWKRGVRIHQFRUSRUDWLRQIRU
ERWKKDYHEHHQ GLIIHQW RZLQJ WR WKH
VWUXFWXUH DQG DYDLODEOH IRUP RI WKH
ILEHUV
7KHWRZIRUPRIILEHUKDVEHHQLQFRUSRUDWHGLQ
WRWKH\DUQ
VWUXFWXUHWIRUPDK\EULGFRUHVKHDWK\DUQZL
WKFDUERQWRZDW
WKHFRUHDQGSRO\HVWHUVWDSOHIRUPLQJWKHVK
HDWKXVLQJ'5()
,,VSLQQLQJWHFKQLTXH)ULFWLRQ'5(),,VSLQQLQJVV
WHPLV
DQ2SHQHQRUFUHVKHDWKVSLQQLQJVV\WHP,WLV
RQHRIWKH SURPLVLQJ VSLQQLQJ PHWKRGV WR
SURGXFH \DUQV IRU WHFKQLFDO
WH[WLOHDSSOLFDWLRQV7KHFRUHLVSRVLWLRQHG
H[DFWOFHQWHUDQG
WKHVSLQQLQJWHQVLRQLVOHVVDVFRPSDUHGWRW
KRWKHUV\WHPV OLNH ULQJ DQG URWRU
VSLQQLQJ V\WHPV 7KH '5() VSLQQLQJ
V\WHPFDQSURGXFH\DUQVZLWKKLJKGHOLYHU\UD
WHDERXW
PPLQ'XHWFRPSOHWHFRYHURIWKHFRUHILODPHQW
V\DUQVFDQ
EHSURGXFHGZLWUHTXLUHGWHQVLOHSURSHUWL
HVE\DOHWLQJFRUH SURSRUWLRQ 9DULRXV FRUH
PDWHULDORV KDYH EHHQ XVHG E\
UHVHDUFKHUV>@>@LQ'5()VSLQQLQJWHFKQLTXHW
KHVHUDQJH

IURPILODPHQWRIV\QWKHWLFILEUHVVRU\DUQRIULJL
GILEUHVOLNH
FDUERQEDVRILORUPHWDOVWUDQGV7KHSUHVHQW
ZRUNIRFXVHVVRQ GHYHORSHPHQW RI HOHFWULFDOO\
FRQGXFWLYH FRUHVKHDWK \DUQV FRPSULVLQJ RI
FDUERQ ILODPHQW DV FRUH DQG SRO\HVWHU
VWDSOH ILEUH DV VKHDWK 3RO\HVWHU ILEUH LV
WUDGLWLRQDOO\ DQ LQVXODWRU DQG LV
VXVFWLWLEOH WR JHQHUDWLRQ RI HOHFWULF
FKDUJHV &DUERQ URYLQJ KDV KLJK HOHFWULFDO
FRQGXFWLYLW\ 7KH FRPELQDWLRQ RI
WKHVHDV\K\EULG\DUQVIRUPDNLQJHOHFWULFDOO\F
RQGXFWLYH\DUQV
KDVEHHQGHSLFWHG7KHZRUNRIGHYHORSHPHQWRIW
KHSWLPLJHG
VWUXFWXUHWIRUWKH\K\EULG\DUQXVLQJ'5(),,VSLQQLQ
JKDVEHHQ
GHVFULEHGLQWKHVXEVHTXHQWVHFWRQV
,QWKHVHFWRQSDUWRUWKHZRUNVWDSOHIRUPRI
WKHFDUERQ
ILEHUKDVEHHQEOHQGHGZLWKSRO\HVWHUVWDSO
HILEHURIVLPLODU SK\VLFD FDUUFDWHULVWLFV
XVLQJ FRQYHQWLRQDO ULQJ VSLQQLQJ
WHFKQLTXH,QRUGHUWRREWDLQDKRPRJHQRXVEOH
QGRISRO\HVWHU DQG FDUERQ ILEHUV EORZURR
EOHQGLQJ KDV EHHQ SUHIHUHG
6LPLODUVWXGLHVVDYHEHHQHSRUWHGRQEOHQG
LQJRIHWDOILEHUV WR GHYHORS FRQGXFWLYH
\DUQV 7KH DLP RI WKH ZRUN ZDV WR
RSWLPLJHWKHSURSRUWLRQRIFDUERQILEHUFHQW
QWLQWKH\DUQV DV WR REWDLQ HOHFWULFDO
FRQGXFWLYLW\ ZLWKRXW VDFULILFLQJ RWKHU
\DUQFKDUDFWHULVWLFV
7KH VXEVHTXHQW VHFWRQV KLJKOLJKW WKH
SURFHVV RI GHYHORSHPHQW RI HOHFWULFDOO\
FRQGXFWLYH \DUQV DQG WKHLU
SURSHUWLHV7KHVH\DUQVVDYHEHHQIXUWKHULQF
RUSRUDWHGDVZHIW LQ IDEULF 7KH IDEULFV
GHYHORSHG KDYH EHHQ IXUWKHU
FKDUDFWHULJHGIRUWKHLUSK\VLFDODQGXQFWLR
QDOSURSHUWLHV

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A. DREF Spinning Parameters-Process and Raw Materials

'5() VSLQQLQJ WHFKQRORJ\ DQ H[SHULPHQWDO
SODQ WR GHYHORS FRQGXFWLYH \DUQV ZLW
FDUERQ FRUH DQG SRO\HVWHU VKHDWK ZDV PDGH
,Q WKLW VWXG\ WKH GHYHORSHPHQW RI K\EULG \DUQ
ZLW FDUERQ URYLQJ FRUH DQG SRO\HVWHU
VWDSOH ILEHUV DV
VKHDWKZDVXQGHUWDNHQHQ'5(),,VSLQQLQJVV\W
PHWDLOVRI
WKHPDWHULDORVXVHGIRUGHYHORSHPHQWRI\DUQV
UHJLYHQQLQJ7DEOH

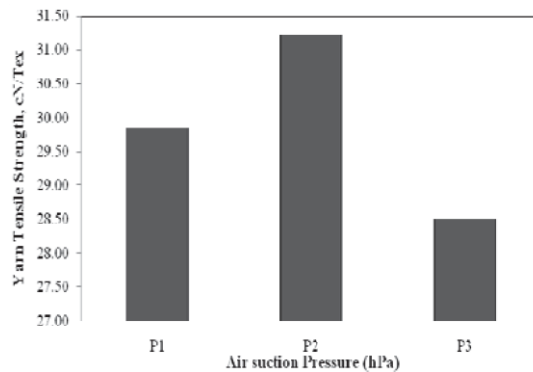
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RSHQLQJ UROOHU
VSHHG DQG DLUVXFWRQRUSUHVVXUHZHUHYDULHG
WRGHYHORSDK\EULG
\DUQRISRO\HVWHUZHVLWKFDERQFRUH.HHSLQLQJYL
HZWKHDLPRI GHYHORSHPHQW LW ZDV IHOW WKDW
WKH FRQGXFWLYLW\ RI WKH K\EULG \DUQ FDQ EH
LPSURYHG E\ UHGXFHQJ LWV UHVLVWLYLW\ 7KH NH\
SDUDPHWHU DYDLDEOH IRU FRQWUROOLQJ LW LV
WKH K\EULG \DUQ GLDPHWHU 2SHQLQJ UROOHU
VSHHG V ZHUH YDULHG DV USP
USPDQG USP7KHGLDPHWHURI\DUQZDVIRXQGWR
EHORZHUIRUKLJKHURSHQLQJUROOHUVSHHGVDQGF
RUHVKHDWKIHHG
UDWLRRI7KLVZDVIXUWKHUDVVLVWHGZLWKLQFUH
DVLQJVFWRQRUSUHVVXUHURUWKHFRPSDFWRQRUWKH\DUQ
7KHVFWRQRUSUHVVXUHZDVIXUWKHUYDULHGIR
URSHQLQJUROOHU VSHHG RI USP ZLWK FDUERQ
SRO\HVWHU IHHG UDWLR WR
VWXG\WKHHIHFWRIVXFWRQRUSUHVVXUHRQ\DUQGL
DPHWHUDQGDUQ
UHVLVWLYLW\7KHUHVXOWRIRWKHVDPHKDYHEHH
QVXPPDULJHGLQ
7DEOH,,WFDQEHVHHQWKDWVWKHVXFWRQRUSUH
VXUHLQFUHDVHV
WKH\DUQGLDPHWHUUHGXFHVRQO\XSWRK3DEH\RQ
GZKLFK FRPSDFWRQ LV QRW SRVVLEOH DQG
WKHUH LV YDULDELOLW\ RI \DUQ
GLDPHWHUWRR7KHYDULDELOLW\LQ\DUQGLDPHWH
UDOVRLQFUHDVHVDV WKH VFWRQRUSUHVVXUH
LQFUHDVHV EH\RQG K3D \$FFRUGLQJ\ WKH
PHFKDQLFDO DQG HOHFWULFDO SURSHUWLHV RI
GHYHORSHG \DUQV KDYHEHHQVKRZQLQJLJ
UHVSHFWLYHO\,WFDQEHVHHQ WKDW DV VFWRQR
SUHVXUH LQFUHDVHV WKH \DUQ VWUHQJWK
LQFUHDVH
DQGWKHQGHFUHDVHEH\RQK3D7KHWUHQGLVVLPL
ODUWRWKDW VHHQ LQ FDUH RI \DUQ GLDPHWHU
7KH SUREDEOH IDFWRUV
LQIOXHQLQJWKLVFRXOGEHWKHLQFUHDVHYDULD
ELOLW\LQWKH\DUQ
GLDPHWHUDWLQFUHDVHGVXFWRQRUSUHVVXUHQDQ
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SUHVXUH RQ
HOHFWULFDOUHVLVWLYLW\RIK\EULG'5()DUQVRI3R
O\HVWHUVKHDWK
ZLWK&DUERQFRUH,WFDQEHVHHQWKDWIRUVXFWR
QRUSUHVVXUHRI
K3DWKHHOHFWULFDOUHVLVWLYLW\LWKHORZHV
W7KH\DUQGLDPHWHU UHGXFHV DV WKH DLU
VFWRQRUSUHVVXUH LQFUHDVHV WLOO K3D
EH\RQG WKLV SUHVXUH WKHUH LV LQFUHDVH LQ
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UHVLVWLYLW\LVRZHVWDWSUHVVXUHRK3D

)LJ,QIOXHQFHRIDLUVXFWRQRUSUHVVXUHRQHOHFWULF
DOUHVLVWLYLW\RI
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\$FFRUGLQJ\DUQSURFHVVVLQJZDVFDUULHGRXW
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VSLQQLQJZLWKIROORZLQJPDFKLQHSUDUDPHWHUV x
UDWLRIRUFURUHYLQJVOLYHUIHHG x
6XFWRQRUSUHVVXUH K3D x 2SHQLQJUROOHUVSHHG
USP x <DUQGHOLYHU\VSHHG PSP x
6SLQQLQJGUXPVSHHG USP

7KH UHVXOWDQW \DUQ ZDV HYDOXDWHG IRU LWV SK\VLFDOPHFKDQLFDODQGHOFWULFDOSURSHUWLHV

B. Ring Spinning – Process and Raw Materials

7KH VWDSOH IRUP RI FDUERQ ILEHU ZDV XVHG IRU GHYHORSLOJ HOHFWULFDODQFRQGXFWLYH\DUQVE\EOHQGLQJLWZLWKSRO\HVWHUDQG VSXQXVLQJULQJVSLOQLQJWHFKQLTXH7KHILEHUGHWDLOVXVHGLQ IRUPDWLRQRIULQJVSXQFRQGXFWLYH\DUQVDUHGHSLFWHGLQ7DEOH

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3URSHUWLHV	&DUERQILEHU	3RO\HVWHUIL EHU
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7KH SRO\HVWHUFDUERQ VWDSOH ILEHUV ZHUH VXEMHFWHG WR EORZURPEOHQGLQJLQYDU\LQJSURSRUWLRQVZLWK SHUFHQWDJH E\ ZHLJKW 7KH ILEHUV ZHUH VSXQ WR D ULQJ VSXQFRXQWR\I\VIH'XULQJWKHVSLOQLQJWULDOVRI\DUQVLW ZDVHQYLVVDJHGWKDWVWKFHFDUERQFRQWHQWLQWKH\DUQZRXOG LQFUHDVH HOHFWULFDOUHVLVWDQFH RI WKH \DUQ ZRXOG UHGXFH +RZHYHU WKH VSXQ \DUQV VKRZHG DV GLIIHUHQW WUHQG \$V WKH FDUERQ ILEHU FRQWHQW LQFUHDVHV LQ \DUQ HOHFWULFDOUHVLVWLYLW\ UHGXFHV EXW WKH WHQVLOH VWUHQJWK RI WKH \DUQ UHGXFHG DV WKH FDUERQ ILEHU FRQWHQW LQFUHDVHV IURP WR)URP WKH WULDOV LW ZDV IRXQG WKDW IRU ¶V 1H \DUQ WKH HOHFWULFDOUHVLVWLYLW\LVORZHUVFRPSDUHGWWR¶V1HDQG¶V1H\DUQV LUHVVSHFWLYHRIWKHSURSRUWLRQRIFDUERQILEH UFRQWHQW 7KH\DUQVZHUHSURFHVHGRQULQJUDPHZLWKWKH IROORZLQJ

SDUDPHWHUV

-)HHGURYLQJKDQN ¶V1H
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7KH UHVXOWDQW \DUQV OLNH WKH '5() VSXQ \DUQV ZHUH HYDOXDWHGIRUWKHLUSURSHUWLHV

C. Fabric Formation Using Developed Conductive Yarn

7KH\DUQVWKXVVSXQZHUHXVHGWRIRUPDWLRQRI IDEULF7KH IDEULF ZHDYLQJ ZDV FDUULHG RXW

XVLQJ SRO\HVWHU ZDUS DQG SRO\HVWHUFDUERQ\DUQDVZHIW,QHDFKRIWKHFVDV HGHSHQGLQJ XSRQWKH\DUQFRXQWVSXQWKHZDUSZDVFKRVHQDS SURSULDWHO\ 7KHGHWDLOVRIWKHIDEULFVDUHUVKZRQLQ7DEOH H,9

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DEULFFRQVWUXFSLRQSDUDPHWHUV	'5)\DUQ	5LQJVSXQ\DUQ
:DUSFRXQW7H[7H[WXUHG3RO\HVWHU ILODPHQW	3RO\HVWHU
:HIWFRXQW7H[3RO\HVWHU&DUERQ '5)\DUQ	3RO\HVWHUFDUERQ
(QGVP 3LFNVFP	,95(68/76	'6&866,21

A. Yarn Parameters

7KH\DUQVVSXQRQ'5()KDGEHHQWHVWHGIRUWKHLUSK\VLFDOSURSHUWLHV OLNH OLQHDUGHQVLW\ DQGGLDPHWHU \$OVR WKH WHQVLOH VWUHQJWK DQG HORQJDWLRQZHUH FKHFNHG RQD XQLYHUVDO WHQVLOH WHVWHU7KHHOHFWULFDODUHVLVWLYLW\RIWKH\DUQZDVPHDVXUHGZLWK KHOSRIDPHJDRKPHWHU7KHUHVXOWVRIWKHVDPHDUHGHSLFWHGLQ 7DEOH9

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2EVHUYHG\DUQGLDPHWUPP
7HQVLOHVWUHQJWKF17H[
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6SHFLILF(OHFWULFDOSHVLVWLYLW\N□JFP

7KH ULQJ VSXQ \DUQV ZHUH DOVR HYDOXDWHG IRU WKHLU SHUIRUPDQFHWKHGHWDLOVRIWKHVDPHDUHUHSRUWHGLQ7DEOH9,

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2EVHUYHG\DUQGLDPHWUPP
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6SHFLILF(OHFWULFDOSHVLVWLYLW\□JFP

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QJZLWK
FDUERQFRUHLVFRDUVHULQGHQLHUDQGKDVKLJKH
UVVUHJQJWK,WKDV DERXW RI SRO\HVWHU
VKHDWK ZUDSSHG DURXQG LW ,W KDV
VWUHJQJWKRIDERXWF17H[,WLVULJLGZLWKORZHOR
QJDWLRQ
RIRQO\,WVVSFLILFUHVLVWDQFHLVN□JFP
7KHULQJVSXQ\DUQKDVVWDSOHILEHUVRIFDUERQE
OHQGHGZLWK
SRO\HVWHU9DULRXVEOHQGVKDGEGHQWULHGRXW
UDQJLQJIURP
WRRIFDUERQILEHU,WZDVIRXQGWKDWKHLQFUHD
VHLQ
FDUERQILEHUFRQWHQWLQWKHEOHQGFDXVHGLU
HJXODULW\DQGORZHU VWUHJQJWK RI WKH \DUQ
7KH UHVXOWDQW \DUQ ZLWK KLJKHU FDUERQ
ILEHUGLQQRVWKRZDQ\VLJQLILFDQWLP SURYHPHQ
WLQHOHFWULFDO
UHVVLVWLYLW\+HQFHEOHQGRISRO\HVWHUFDUERQZ
DVIRXQGW
EHRSWLPXP7KHVHILEHUVDUHKRPRJHQRXVO\VSUH
DGLQWRWKH
PDWUL[RIDUQ7KH\DUQLVILQHUOHVVEXON\LQGLDP
HWHU,WKDV UHODWLYHO\ ORZHU VWUHJQJWK DQG
HOHFWULFDO FRQGXFWLYLW\ ,W LV FRPSRVHG RI
GLVFRQWLQRRXV VWUDQGV RI FRQGXFWLYH
FDUERQ VWDSOH ILEHUV 7KH \DUQ KDV VWUHJQJWK
RI F1WH[DQG
HORQJDWLRQRI,WLVUHODWLYHO\PRUHSOLDEOHDV
FRPSDUHG
WR'5)VVSXQ\DUQDQKDVVVSFLILFHOFWULFDOUH
VLVWLYLW\ORZHU WKDQ'5)\DUQDERXWN□JFP
7KH\DUQVZLWKLQFRUSRUDWHGFDUERQILEHUVL
QGLIHUHQWIRUP
KDYHVKRZQHOFWULFDOUHVLVWDQFHLQGLVLS
DWLYHFUHQWUDQJH
+HQFHGSHQGLQJXSQRWKHLUSK\VLFDQFKDUDFWH
ULVWLFVFRXOGILQG
DSSOLFDWLRQDVYDULRXVVDWLFGLVLSDWLYHI
DEULFV

B. Fabric Parameters

7KH IDEULFV KDG EHHQ GHYHORSHG XVLQJ
FRQGXFWLYH \DUQV
ERWKULQJVSXQDVZHOODV'5)VVSXQ7KHIDEULFFRQV
WUXFWLRQ LQ HDFK FDVH XVHG ZDUS RI D
SRO\HVWHU ILODPHQW ZLWK
FRXQWFRPSDWLEOHZLWKWKHFRQGXFWLYHZHIWE
HLQJXVHG+HQFH
LQIDEULFVDPGHRXWRI'5)VVSXQFRQGXFWLYHZHIW'
7H[WXUHG3RO\HVWHUKDGEHQXVHGZDUSZLWK
VHWWRI[SHU FP 7KH IDEULF FRQVWUXFWLRQ XVLQJ
ULQJ VVSXQ FRQGXFWLYH
\DUQDVZHIWKDVXVHG7H[WH[WXUHGZDUSZLWKDV
HWRI [Wkuhdgv SHU FP WKH IDEULFV KDG EHHQ
WHVWHG IRU WKHLU SK\VLFDQ DQG IXQFWLRQDO

SURSHUWLHV WKH VXPPDU\ RI WKH
REVHUVDWLRQVDUHVKRZQLQ7DEOH9,,

7\$%/(9,,
3523(57,(62))\$%5,&6;7+&\$5%21%(1'&21'8&7,9(:07

)DEULF FRQVWUXF WLRQ	RO\HVWHUWH[WXUHG ZDUS	3RO\HVWHUZDUS 3RO\HVWHU& DUERQ '5)VVSXQZHIW	3RO\HVWHU&DUER Q5LQJ VVSXQZHIW
)DEULF JUDPPDJH JVTP)DEULF WKLFNQHVVP P 6XUIDFH UHVVLVWLYLW \N□ 6WDWLF'HFD \ WLPHWV			

7KHUHVXOWVVRIVXUIDFHUHVVLVWLYLW\RIIDEULF
VGHPRQVWUDWHWKDW WKH IDEULFV ZLWK '5)
FRQGXFWLYH ZHIW KDV ORZHU VXUIDFH
UHVVLVWLYLW\ RI N RU JUHDWHU HOHFWULFDO
FRQGXFWLYLW\
+RZHYHUWKHIDEULFZLWKULQJVSXQFRQGXFWLYH\
DUQKDVKLJKHU VXUIDFHUHVVLVWLYLW\RI
7KLVDQEHDDWUWLEXWHGWRWKH FRQGXFWLYH
FRUHI '5) VVSXQ \DUQV WKDW FRQWULEXWHV
DERXW RI WKH \DUQV 7KHU DUH VHYHDO
IDFWRUV UHVSQRVLEOH
WRZDUGVWKLVEHKDYLRU7KHVWDSOHILEHUVDUH
LQKHUHQWO\ORZHULQ
FRQGXFWLYLW\WKDQFDUERQFRUHI7KHFRUHLQ'5)\D
UQVFDQEH FRQYHQLHQWO\ ZUDSSHG ZLWK
3RO\HVWHU ILEHU VKHDWK EXW ULQJ VSLQQLQJ RI
SRO\HVWHUFDUERQ EOHQGV PDNHV LW GLILFXOW
WR KDQGOH WKH ULJLG FDUERQ ILEHU DW FDUGLQJ
DQG GUDZLQJ VWDJH
+HQFHLQFUHDVLQJWKHSHUFHQWJHRIFDUERQILE
HULQWKHEOHQ
KDVVKRZQORVVLQVWUHJQJWKDQGLUHHJXODULW\
RIWKH\DUQV7KH \DUQ VVSXQ RXW RI WKHVH
GLVFRQWLQRRXV VWUDQGV KDV KLJKHU
UHVVLVWDQFHDQGFQFRQVHTXHQWO\WKHIDEULFVXVL
QJFDUERQILEHU JLYHUHVVLVWDQFHRIRUGHUN
\$OVRWKH6WDWLF'HFD\WHVW
FRQGXFWHGIRUWKHGHYHORSHGIDEULFVKDVVCRZ
QWKDWWKHIDEULF
ZLWK'5)VVSXQ3RO\HVWHU&DUERQ\DUQLQZHIWZRX
OGVHUHYHDV
DQH[FHOHQWVVDWLFGLVLSDWLYHIDEULFZLWK
VWDWLFKDOIWLPHGHD\ W RI VHRQGV +RZHYHU
WKH IDEULF ZLWK ULQJ VVSXQ
SRO\HVWHUFDUERQEOHQKDVVVDWLFKDOIWLP
GHFD\WRI VHRQGV 7KLVLGLIHUHQFH FDQ EH

DWWULEXWHG WR WKH DYDLODEOH FRQWLQRRXV
FRUH RI FDUERQ ILODPHQW LQ FRUH RI '5() VSXQ
\DUQV1HYHUWKHOHVVDFFRUGLQJWR6WDQGDUQ(1
±
GLVVLSDWLYHHOHFWURVVDWLFDPDWHULDOLVWK
DWLQZKLFKWKKDOIGHFD\
WPLHLVWVRUWKHVXUIDFHUHVLVWDQFHîöRQRQH
VXUIDFH DW OHDVW >@ %RWK WKH GHYHORSHG
IDEULFV IXOILOO WKLW FRQGLWLRQ IRU
HOHFURVVDWLF GLVVLSDWLRQ +HQFH LW PD\ EH
REHVUYHG WKDW WKH IDEULFV GHYHORSHG RXW
RI ERWK WKH \DUQ
VWUXFWXUHVFDQEHXVHGVDVHOHFURVVDWLFGL
VVLSDWLYHWH[WLOHV7KH DSSOLFDWLRQ ZRXOG
GLIIHU IURP DSSDUHO WR XSKROVWHU\
GHSHQGLQJXSQRQWKHFRQVWUXFWLRQRIWKHPDWH
ULDO